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Numerical modeling of the phase separation process driven by a porous membrane

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The separation of liquid and gas phases using porous media has been considered for various applications such as propellent management in aerospace, petroleum engineering, carbon storage and so on. However, such a process is usually difficult to model as the multiphase flow involving porous media usually spans several characteristic lengths, and the interface conditions between the free fluid and the porous media flow are relatively complex. A direct numerical simulation (DNS) using fully resolved Navier-Stokes equations is limited by the immense computational cost. In this work, a mixed-dimensional flow model was developed for the highly coupled free fluid and thin porous media flow, in which the flow process in the porous membrane was reduced to one dimension. Besides, the parameter transfer equations at the regional interface were evaluated, and the proposed model was validated against DNS results. The effects of pore structures, porosity, and flow direction on the two-phase transport process were studied in detail. The present study will provide guidance for the optimization of phase separation systems driven by thin porous media.

Keywords: phase separation, multiphase flow, numerical modeling, coupled flow, porous media

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